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DEPARTMENT OF THE ARMY, TULSA DISTRICT CEGS-02230 (JAN 97)
U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT GUIDE SPECIFICATION

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SECTION 02230

STONE PROTECTION

1 GENERAL

1.1 SUMMARY

This section covers riprap, [quarry run stone], and bedding stone protection.

1.2 REFERENCES

The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS

ASTM C 88	(1990) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
ASTM C 127	(1988; R 1993) Specific Gravity and Absorption of Coarse Aggregate.
ASTM C 535	(1989) Resistance to Abrasion of Large Size Coarse Aggregate by Use of the Los Angeles Machine.
ASTM C 131	(1989) Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

US ARMY CORPS OF ENGINEERS HANDBOOK FOR CONCRETE AND CEMENT:

CRD-C 137	(1977) Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
CRD-C 144	(1973) Method of Testing Stone for Resistance to Freezing and Thawing

1.3 MEASUREMENT AND PAYMENT

NOTE: Use Alternate 1 for payment by the ton and Alternate 2 for payment by Cubic Yard.

ALTERNATE 1

Measurement for stone protection material shall be the number of metric tons tons (2000 pounds) of bedding, [quarry run stone], or riprap determined from truckload weighbills delivered to the the Contracting Officer for material placed and accepted in the completed work. Deductions will be made for any material wasted, unused, rejected, or used for convenience of the Contractor.

Stone protection materials will be paid for at the respective contract unit price for the Bidding Schedule item "Riprap" or "Bedding" as applicable, which will constitute full compensation for the construction and completion of the work.

ALTERNATE 2

Maesurement of the respective stone protecteion materials will be by the volume determined by multiplying the area of the surface on which the stone is placed by the thickness of the stone dimensioned on the drawings. Payment for stone protection material will be made at the respective contract price per cubic meter yard for the appropriate item. No payment will be made for excess thickness layers nor for material required to replace embankment or subgrade material lost by rain wash, wind erosion, or otherwise, except for additional bedding material ordered in writing by the Contracting Officer.

1.4 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 - SUBMITTAL DESCRIPTIONS:

SD-14 Sample

Stone Protection Materials; [ ]

Samples of stone protection materials of each type.

1.5 PRE-PRODUCTION QUALITY CONTROL

1.5.1 Testing

Suitable prior tests and service records will be used to determine the acceptability of the stone protection materials. If suitable test reports and a service record that are satisfactory to the Contracting Officer, are not available, as in the case of newly operated sources, the material shall be subjected to such tests as are necessary to determine its acceptability for use in the work. Tests to which the materials may be subjected include petrographic analysis, specific gravity, abrasion, absorption, wetting and drying, freezing and thawing, and such other tests as may be considered necessary to demonstrate to the satisfaction of the Contracting Officer that the materials are acceptable for use in the work. All tests will be made by or under the supervision of the Government and at its expense. Tests and test values listed hereinafter are for job controls of riprap and will be used to determine the acceptability of riprap material being produced.

1.5.2 Sampling for Acceptability Testing

If acceptability testing is required, the sources from which the Contractor proposes to obtain the material shall be selected well before the material will be required in the work. Suitable test samples of stone protection material shall be obtained by the Contractor under the direct supervision of the Contracting Officer, and shipped or delivered as follows:
(a) Riprap Samples: Samples shall be shipped to the Southwestern Division Laboratory, Corps of Engineers, 4815 Cass Street, Dallas, TX 75235.
(b) Bedding Material Samples: Samples shall be delivered to a point at the project site designated by the Contracting Officer.

Test samples shall be submitted at least 60 days before the time the placing of the stone protection is expected to begin. Stone protection material shall not be delivered to the site of the work prior to approval of the test samples. The total overall weight of the sample of material proposed for riprap shall be approximate 375 kg 1,000 pounds and representative pieces shall weigh not more than 37 kg 100 pounds. The total overall weight of each sample of material proposed for bedding shall approximate 37 kg 100 pounds and representative pieces shall weigh not more than 10 kg 25 pounds. If the protection stone is obtained from more than one source, samples of the proposed stone shall be submitted from each source.

2 PRODUCTS

2.1 STONE PROTECTION MATERIALS, GENERAL

Stone for the protection work shall be durable stone as approved by the Contracting Officer. Gypsum, anhydrite, chert, shale, and soft or weathered rock will not be approved. Stone protection material meeting the quality requirements of these specifications is not available from required excavation. The Contractor shall make all arrangements for procuring, loading, hauling, handling, and placing all stone protection materials from offsite sources. Properties of the riprap and bedding materials shall be as follows:

2.1.1 Weight and Absorption

The minimum weight per solid cubic foot calculated from the bulk specific gravity (saturated surface-dry) of the sample determined in accordance with the procedure in ASTM C 127, shall be 52.25 kg 140 pounds. Absorption shall not exceed 6 percent by weight.

2.1.2 Soundness (Freezing and Thawing Test)

The loss weight of stone after 20 cycles of freezing and thawing with test specimen immersed in water shall be less than 15 percent. Each cycle shall consist of 16 hours freezing at temperature of -15 C 5 degrees F, and 8 hours thawing at temperature of 38 C 100 degrees F. The test specimens shall be prepared in accordance with the requirements of CRD-C144, and shall consist of the 38 mm to 64 mm 1-1/2-inch to 2-1/2-inch size aggregate.

2.1.3 Soundness (Magnesium Sulfate Test)

The loss of weight of stone after testing with 5 cycles of magnesium sulfate shall not exceed 18 percent. The tests shall be in accordance with the procedures designated in CRD-C 137 and ASTM C 88. The tests shall be performed on 38 mm to 64 mm 1-1/2- to 2-1/2-inch size aggregate.

2.1.4 Resistance to Abrasions

Stone shall be subjected to the Los Angeles Abrasion Test (ASTM C 131) and shall show a loss in weight of not more than 45 percent after 500 revolutions.

2.2 BEDDING

Bedding material shall consist of sand, gravel, or crushed stone, well-graded between the prescribed limits as specified in paragraph "Bedding Layers." The material shall be composed of tough, durable particles, shall be reasonably free from thin, flat and elongated pieces, and shall contain no organic matter or soft, friable particles in quantities more than 5 percent of the total sample. Bedding material shall conform to the requirements of paragraph

"Bedding Material" and shall be reasonably well-graded within the following limits:

Sieve Designation U. S. Standard Square Mesh (Inch)	Percent by Weight Passing
6	100
4	85-100
2	60-80
1	35-60
3/8	10-35
No. 4	0-15

Sieve Designation U. S. Standard Square Mesh (mm)	Percent by Weight Passing
150	100
100	85-100
50	60-80
25	35-60
9.5	10-35
0.6	0-15

2.3 RIPRAP

Stone for riprap shall be durable and of a suitable quality to insure permanence in the structure and in the climate in which it is to be used. It shall be free from cracks, seams, and other defects that would tend to increase unduly its deterioration from natural causes. The inclusion of objectionable quantities of dirt, sand, clay, and rock fines will not be permitted. Either boulders or quarried rock may be used. The stone shall be reasonably well graded from the minimum size stone permitted to the maximum size stone permitted. Neither the breadth nor the thickness of any piece of stone shall be less than one-third of its length. During production, the stone will be sampled as often as deemed necessary by the Contracting Officer to determine compliance with the provisions of the specifications. The Contractor shall provide all necessary equipment and labor for the taking, processing and weighing of representative samples. Gradations shall be as follows:

RIPRAP GRADATIONS FOR WAVE PROTECTION 1

Riprap Thickness (Inches)	Maximum Size (Pounds)	90 Percent Size2 (Pounds)	Average Size3 (Pounds)	8-percent Size4 (Pounds)
12	150	85-130	30-45	5
18	475	275-435	100-150	15
24	1125	670-1030	250-360	35
30	2240	1300-2000	500-700	70
36	3850	2250-3480	870-1200	120

RIPRAP GRADATIONS FOR STREAMBANK PROTECTION 1

Riprap Thickness (Pounds)	Maximum Size (Pounds)	90 Percent Size2 (Pounds)	Average Size3 (Pounds)	8-Percent Size4 (Inches)
12	90	50-80	20-30	3
15	170	100-155	40-55	5
18	290	170-265	65-90	9
21	465	270-415	105-145	14
24	690	405-620	155-215	22
27	985	575-885	220-310	31
30	1350	790-1215	305-420	42
33	1800	1055-1620	405-560	56
36	2330	1365-2095	525-730	73

1Gradation is for stone having a specific gravity of 2.65.

2Defined as that size such that 90 percent of the stone, by weight, is smaller and 10 percent larger.

3Defined as that size such that 50 percent of the total riprap stone, by weight, is larger and 50 percent is smaller.

4Not more than 8 percent of the riprap, by weight, shall consist of pieces weighing less than the weights shown for the applicable riprap thickness.

RIPRAP GRADATIONS FOR WAVE PROTECTION 1

Riprap Thickness (mm)	Maximum Size (kg)	90 Percent Size2 (kg)	Average Size3 (kg)	8-percent Size4 (kg)
300	68	39-59	14-20	2
400	215	125-197	45-68	7
600	510	304-467	113-163	16
750	1016	590-907	227-318	32
900	1746	1021-1742	395-544	54

RIPRAP GRADATIONS FOR STREAMBANK PROTECTION 1

Riprap Thickness (Inches)	Maximum Size (Pounds)	90 Percent Size2 (Pounds)	Average Size3 (Pounds)	8-Percent Size4 (Pounds)
300	41	23-36	9-14	1
375	77	45-70	18-25	2
400	132	77-120	29-41	4
525	211	122-188	48-66	6
600	313	184-281	70-98	10
675	447	261-401	100-141	14
750	612	358-551	138-191	19
825	816	479-735	184-254	25
900	1057	619-950	238-331	33

1Gradation is for stone having a specific gravity of 2.65.

2Defined as that size such that 90 percent of the stone, by weight, is smaller and 10 percent larger.

3Defined as that size such that 50 percent of the total riprap stone, by weight, is larger and 50 percent is smaller.

4Not more than 8 percent of the riprap, by weight, shall consist of pieces weighing less than the weights shown for the applicable riprap thickness.

2.4 QUARRY RUN STONE

Either boulders or quarried rocks may be used for quarry-run stone. Stone shall be free from overburden spoil, except dirt and fines accumulated from interledge layers or from blasting or loading operations may be permitted up to 8 percent by weight of total sample tested passing the 13 mm 1/2-inch square mesh sieve. Quarry run stone gradations shall be as follows:

QUARRY RUN STONE GRADATIONS

		Intermediate Size(lb)	
Thickness	Max. Size(lb)	40 Percent Size1	Min Size2
12"	See note below	50	< 8% - 1/2"
18"	250	100	< 8% - 1/2"
24"	500	100	< 8% - 1/2"
30"	1000	200	< 8% - 1/2"
36"	2000	400	< 8% - 1/2"
42"	3000	600	< 8% - 1/2"

1 Of any size tested 40% shall consist of stone weighing more than the intermediate size.
2 Less than 8% by weight passing the 1/2 inch sieve.
Note: Shall consist of rock spalls and shall be reasonably well graded between the sizes of 8" and 3", with not more than 5% passing a 3" sieve.

Size	Approx. Wt.
8"	40#
6"	20#
5"	15#
4"	6-8#
3"	3-5#

QUARRY RUN STONE GRADATIONS

		Intermediate Size(kg)	
Thickness	Max. Size(kg)	40 Percent Size1	Min Size2
300	See note below	23	< 8% - 13 mm
450	113	45	< 8% - 13 mm
600	227	45	< 8% - 13 mm
750	454	91	< 8% - 13 mm
900	907	181	< 8% - 13 mm
1050	1361	272	< 8% - 13 mm

1 Of any size tested 40% shall consist of stone weighing more than the intermediate size.
2 Less than 8% by weight passing the 13 mm sieve.
Note: Shall consist of rock spalls and shall be reasonably well graded between the sizes of 200 mm and 75 mm, with not more than 5% passing a 75 mm sieve.

Size (mm)	Approx. Wt.(kg)
200	18

150	9
125	7
100	3-4
75	1-2

3 EXECUTION

3.1 FOUNDATION PREPARATION

Clearing, grubbing, and debris removal shall be as specified in Section 02050 - CLEARING AND GRUBBING. Excavation and fill shall be as specified in Section 02200 - EARTHWORK. Areas on which bedding is to be placed shall be trimmed and dressed to conform to cross sections shown on the drawings within an allowable tolerance of plus or minus 50 mm 2 inches from the theoretical slope lines and grades. Where such areas are below the allowable minus tolerance limit they shall be brought to grade by filling with earth similar to the adjacent material and well-compacted or by filling with bedding material and no additional payment will be made for any material thus required. Immediately prior to placing the bedding, the prepared base will be inspected by the Contracting Officer and no material shall be placed thereon until that area has been approved.

3.2 BEDDING PLACEMENT

Bedding material shall be placed within the limits shown on the drawings or as staked in the field. Prior to placing bedding, filter cloth shall be placed on the proposed grade in accordance with SECTION 02215 - PLASTIC FILTER CLOTH. Bedding material shall be spread uniformly on the prepared base, in a satisfactory manner, to the slope lines and grades indicated on the drawings or as directed. Placing of material by methods which will tend to segregate particle sizes within the bedding will not be permitted. Any damage to the surface of the bedding base during placing of the bedding shall be repaired before proceeding with the work. Unless otherwise specified, compaction of the bedding layers will not be required but they shall be finished to present a reasonably even surface free from mounds or windrows. A tolerance of plus or minus one inch from the thickness indicated on the drawings will be allowed in the finished surface of the bedding.

3.3 RIPRAP PLACEMENT

Riprap shall be placed within the limits shown on the drawings or otherwise required by the Contracting Officer. Stone for riprap shall be placed on the bedding layers in a manner to produce a reasonably well-graded mass of rock with a minimum of of voids, and shall be constructed within the specified tolerance to the lines and grades shown on the drawings or staked in the field. Grade stakes shall be set at intervals not to exceed 15 meter 50-foot centers longitudinally and transversely, and at points of grade change. A tolerance of plus 150 mm 6 inches from the thickness shown on the drawings will be allowed in the finished surface of the riprap and isolated stones may extend as much as 150 mm 6 inches above grade. Where thickness of riprap exceeds the allowable tolerance, excess riprap shall be redistributed or removed from the work. Riprap removed from the work shall be reweighed for deduction from the quantity to be paid for. No minus tolerance will be permitted. Riprap shall be placed to its full course thickness in one operation and in a manner to avoid displacing the bedding material. The larger stones shall be well distributed and the entire mass of stones in their final position shall be roughly graded to conform to the gradation specified above. The finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Placing

riprap in layers will not be permitted. Placing riprap by dumping into chutes or by similar methods likely to cause segregation of the various sizes will not be permitted. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source; by controlled dumping of successive loads during final placing, or by other methods of placement which will produce the specified results. Rearranging of individual stones by mechanical equipment or by hand shall be performed as required to obtain a reasonably well-graded distribution of stone sizes as specified above. Any unsuitable riprap placed in the work shall be removed from the work and reweighed for deduction from the quantity to be paid for. Finishing operations shall not lag initial placement operations more than 60 meters 200 feet. Unless otherwise authorized by the Contracting Officer, riprap protection shall be placed in conjunction with the construction of the embankment and with only sufficient lag in construction of the riprap as may be necessary to prevent mixture of embankment and stone protection materials. The Contractor shall maintain the riprap protection until accepted and any material displaced by any cause shall be replaced at his expense to the lines and grades shown on the drawings.

3.4 QUARRY RUN STONE PLACEMENT

Quarry-run stone for protection shall be placed in such manner to produce a reasonably well-graded mass of rock with the minimum practicable percentage of voids. The rock shall be placed by dumping to its full thickness in one operation. The larger stones shall be well distributed and the entire mass of stones in their final position shall conform to the gradation requirements specified above. The Contractor shall maintain the stone protection until accepted and any material displaced by any cause shall be replaced. Unless otherwise authorized by the Contracting Officer, the stone shall be placed in conjunction with the construction of the embankment and with only sufficient lag in the construction of the quarry-run stone as may be necessary to prevent mixture of embankment and stone protection materials. A tolerance of plus 150 mm 6 inches from the slope lines and grades shown on the drawings will be allowed in the finished surface of the quarry-run stone.

3.5 PRODUCTION QUALITY CONTROL

3.5.1 Government Sampling and Testing

During construction, stone protection materials will be sampled and tested as often as deemed necessary by the Contracting Officer. This testing will consist of inplace gradations and quality tests on the placed and finished stone. The Contractor shall furnish three laborers as required to assist in the sampling and testing, the necessary equipment and operators for performance of the sampling and testing, and shall be responsible for the satisfactory replacement of stone in the sampled area, all at no additional cost to the Government.

3.5.2 Riprap [and Quarry Run Stone] Gradation Test and Depth Checks

The inplace gradations and depth checks will be determined using the following procedure:

(1) Selection of a full thickness sample at least 2.5 meters 8 feet square from the placed and finished stone.

(2) Determination of the weight of the entire sample and average depth of the area from which the sample was removed.

(3) Determination of the weight of each individual piece of stone weighing over the specified 8 percent size.

(4) Determination of the collective weight of all individual stones weighing less than the specified 8 percent weight.

The number of passing tests that the Government will conduct will not exceed two for 300 mm 12-inch riprap; however, only those tests which meet all the specified requirements will be counted. If any test indicates the materials or workmanship does not conform to the specifications, the material shall be removed and replaced with stone meeting these specifications; the frequency of testing will be increased until compliance has been obtained.

3.5.3 Bedding Gradation Tests and Depth Checks

The inplace gradations and depth checks will be determined prior to placement of riprap using the procedure described in EM 1110-2-1906, "Laboratory Soils Testing." The number of passing tests the Government will conduct will not exceed two for bedding material. If any tests indicate the materials or workmanship does not conform to the specifications, the material shall be removed and replaced with stone meeting these specifications; the frequency of testing will be increased until compliance has been obtained.